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An Attempt to Detect Some Electro-Optical Effects

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Summary.

The principal results obtained in this paper may be summarised as follows:—

(1) When radium emanation, in radio-active equilibrium with its products of disintegration, is condensed at the bottom of an evacuated tube immersed in liquid air, active deposit particles are radiated up the tube. This phenomenon is ascribed to the recoil of the residual atom when an α-particle is emitted.

(2) The law of absorption of this radiation both in air and hydrogen has been investigated. The radiation reaching a surface at a fixed distance from the condensed emanation is an exponential function of the gas pressure.

(3) From the rate of decay of the activity collected on a surface exposed to the radiation from the emanation, it appears that both radium A and radium B reach the surface.

(4) Radium B and radium C are both radiated through a vacuum from a surface previously rendered active by exposure to the emanation. Supposing that radium B emits only β-particles, the radiation of radium C must be due to the recoil of the atoms when β-particles are emitted.

The work has been greatly facilitated by the kindness of Prof. Rutherford in supplying us with the emanation necessary for these experiments. We take this opportunity of expressing our thanks to him.

An Attempt to detect some Electro-optical Effects.

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The following paper contains a description of some experiments made with the object of detecting possible effects due to electric and magnetic fields and moving matter on the velocity of propagation of light in glass. The results obtained were negative, but it seems worth while to publish a short account of the experiments.

The optical part of the apparatus is a simple form of interferometer which proved very easy and convenient to work with. It consists of a square glass frame made up of glass bars of square cross-section cemented together with canada balsam. Three of the corners are cut off at 45°, as shown in the figure, and the fourth corner contains a half silvered surface FF. Light entering in the direction of the arrow A is divided into two beams by the silver film, which pass round the frame in opposite directions, being totally reflected at the cut-off corners. Half of each beam emerges in the direction of the arrow B, and the two beams at B are in a condition to interfere with each other.

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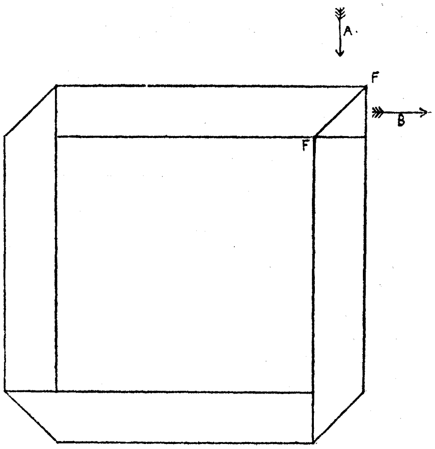
The frame is so constructed that an eye at B observing a source of white light at A by reflexion round the frame sees a system of interference bands. If the frame is supported horizontally and is at an uniform temperature the bands are nearly circular with the centre of the system in the middle of the field. The bands are more or less distorted by slightly warming the frame unequally, *e.g.* by taking hold of one of the bars, but the distortion is small and varies slowly. The glass bars are 2 cm. thick, and the outside breadth of the frame is 14 cm. The path of a ray going once round the frame is 44 cm. long inside the glass from the silver film and back to it. The refractive index of the glass for sodium light is 1·67.



In all the experiments described below the interference bands were observed in a telescope provided with cross wires. The bands were widely separated, and I think a displacement or broadening of a band amounting to one-fiftieth part of the distance between two bands could have been detected. To produce this effect would require the velocity of one ray to be increased and that of the other to be diminished by one part in ten millions.

The effect of a rapidly alternating induced electromotive force acting round the frame was first tried. A coil of insulated wire of about 150 turns and 9 cm. in diameter was wound on a glass cylinder and put through the frame so that the axis of the coil was perpendicular to the plane of the frame.

A powerful jar discharge from two quart jars and a 10-inch coil was passed through the coil to produce an intermittent rapidly alternating induced electric force round the glass frame. Since the alternating field is only on for a small fraction of the time that the coil is working, if a steady source of light were used to produce the bands a displacement would be difficult to observe. This difficulty was avoided by using the sparks of the jar discharge as the source of light. The light from the sparks is a maximum when the rate of variation of the induced electric force is a maximum. If a varying electric force acting round the frame increased the velocity of one ray and diminished that of the other, the alternating field, using the sparks as the source, would have produced an apparent doubling of the bands, or at least a broadening of them. A faint steady source of light was used in addition to the sparks, and the bands due to the sparks appeared to coincide

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exactly with those due to the steady source. This experiment shows that there is no effect due to a rapidly varying electric force acting round the frame. The rate of variation of the induced electric force in the glass in this experiment was about one million volts per cm. per sec.

Another experiment was then tried, using sparks from a secondary coil of two turns wound round the coil of 150 turns as the source of light. In this experiment the light was a maximum when the induced force was a maximum. Again no effect was observed.

The same two experiments were then repeated with a coil of two turns instead of the coil of 150 turns, with similar results. A small Hertz oscillator, with its axis along the axis of the frame, was then tried, using the sparks of the oscillator as the source of light, without effect.

A single layer of about 100 turns of wire was then wound on the bars of the frame so as to produce a magnetic field round the frame. A powerful jar discharge was passed through this coil without effect, using both primary and secondary sparks as the source of light.

The frame was now fixed up round the poles of a large Du Bois magnet which were put close together. The core of the magnet is 8 cm. in diameter, and it is wound for 100 volts. The magnet was connected directly to an electric supply at 200 volts, and the current started, stopped, and reversed without effect.* The connections to one of the coils of the magnet were then reversed so that both poles could be magnetised in the same way so as to produce a radial field at the glass frame. No effect was obtained.

The frame was next put between two parallel metal plates, 2 cm. apart, which were connected to a Wimshurst electrical machine, and charged up till sparks passed between them. A very slight motion of the bands was observed when the sparks passed, which was no doubt due to the frame being strained by the electrostatic forces. Holes were cut in the plates so that the frame and plates could be put round the poles of the Du Bois magnet. In this way the effect of a radial magnetic field with a perpendicular electric field was tried. Reversing the magnetic field while the electric field was steady produced no effect. In this experiment, according to Poynting's theorem, there was a flow of electromagnetic energy round the frame inside the glass. Indiarubber tubing was then wound round the bars of the frame until the hole through the frame was nearly filled with the turns. A rapid stream of water was passed through the tubing without any effect on the interference bands. The glass frame was very excellently made and adjusted by Adam Hilger, Ltd., and it has remained in perfect adjustment and never given the slightest trouble.

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* The total current flowing round the core was 70,000 amperes. The axis of the frame coincided with the axis of the core.